DOCUMENT RESUME

ED 139 645 SE 022 460

AUTHOR Even, Alexander
TITLE Changes in Grade 12 Chemistry Achievement Patterns in Ontario After Establishment of a Modern Course of Study.
PUB DATE Mar 77
NOTE 13p.; Paper presented at the annual meeting of the National Association for Research in Science Teaching (50th, Cincinnati, Ohio, March 22-24, 1977)

EDRS PRICE MF-$0.83 HC-$1.67 Plus Postage.
DESCRIPTORS *Academic Achievement; *Chemistry; Comparative Analysis; *Curriculum; Educational Innovation; *Educational Research; Science Education; Secondary Education; *Secondary School Science
IDENTIFIERS *Ontario; Research Reports

ABSTRACT

This study replicates part of a 1964 study designed to examine variations in the attainment of cognitive objectives in high school chemistry. In 1964 a traditional curriculum was used, but by 1972 when the data for this study were collected, a modern course based on CHEM study was being used. Scores on a 60-item end-of-course test given to different samples of students before and after establishment of the new course are compared. Students also wrote a scholastic aptitude test, the Inventory of Choices, and a summary of their educational plans. An adaptation of two-way analysis of variance was used to analyze the residual chemistry scores. Among the findings were: (1) the aptitude scores of the 1972 group were substantially lower than those of the 1964 group; (2) substantial declines in achievement were observed across all four levels of the Bloom's Taxonomy; and (3) a substantial portion of the students in the 1972 sample had a pattern of achievement in which their performance in categories 2.00, 3.00, or 4.00 appeared to be tied to the ability to recall factual knowledge (category 1.00). (MH)

****
* Documents acquired by ERIC include many informal unpublished *
* materials not available from other sources. ERIC makes every effort *
* to obtain the best copy available. Nevertheless, items of marginal *
* reproducibility are often encountered and this affects the quality *
* of the microfiche and hardcopy reproductions ERIC makes available *
* via the ERIC Document Reproduction Service (EDRS). EDRS is not *
* responsible for the quality of the original document. Reproductions *
* supplied by EDRS are the best that can be made from the original. *
****

ED139645

U.S. DEPARTMENT OF HEALTH, EDUCATION & WELFARE
NATIONAL INSTITUTE OF EDUCATION

THIS DOCUMENT HAS BEEN REPRODUCED EXACTLY AS RECEIVED FROM THE PERSON OR ORGANIZATION ORIGINATING IT. POINTS OF VIEW OR OPINIONS STATED DO NOT NECESSARILY REPRESENT OFFICIAL NATIONAL INSTITUTE OF EDUCATION POSITION OR POLICY.

CHANGES IN GRADE 12 CHEMISTRY ACHIEVEMENT PATTERNS IN ONTARIO AFTER ESTABLISHMENT OF A MODERN COURSE OF STUDY

Alexander Even
The Ontario Institute for Studies in Education
252 Bloor Street West
Toronto, Ontario, Canada M5S 1V6

Paper read at the annual meeting of the
National Association for Research in Science Teaching,
March 22, 1977, in Cincinnati, Ohio

SE 022 460

This study replicates part of a 1964 Ontario study (Even, 1968) designed to examine variations in the attainment of cognitive objectives in Grade 12 Chemistry. In 1964 most Ontario students were pursuing a "traditional" course of study. During the latter half of the sixties the traditional course gave way to a "modern" type of course heavily influenced by CHEM Study. Considerable adaptation of courses of study to meet local needs was encouraged, and considerable modernization of chemical content was introduced. Perhaps the most noteworthy change in the study of chemistry at the secondary school level was the declared shift in emphasis from acquisition of factual knowledge to the development of higher cognitive skills. By 1972, the year in which data for this study were collected, course innovations and experimental tryouts had consolidated.

As a result of the changes in curriculum it is reasonable to expect that patterns of achievement would change in the directions of greater heterogeneity and increased attainment of higher cognitive skills. Therefore it was considered appropriate to compare patterns of achievement before and after establishment of the modern type of course. Patterns of achievement were sought in profiles of residual achievement scores in the selected processes of *Knowledge*, *Comprehension*, *Application* and *Analysis* described in the Taxonomy of Educational Objectives: Cognitive Domain (Bloom et al, 1956). Patterns of achievement were compared in groups differing in aptitude, attitude and educational plans.

In the 1964 sample a 60 item end-of-course test, developed over a three-year period, was administered to over two thousand students in 30 Ontario high schools that had been selected at random. Since there had been considerable changes in course content, the test could not be used in its entirety in 1972. A panel composed of experienced teachers and other science educators identified 35 of the 60 items as still having high content validity for the 1972 administration. Additional items were constructed, critically revised by the panel, and then added to the 35 items to make a new test. The new test and the old were equated by the Rasch method (Wright 1967, Wright & Panchapakesan 1969, Wright & Douglas, 1975) so that any given score on the 1972 test could be expressed in terms of an equivalent 1964 score. Equating of the aptitude measures also was necessary since the aptitude test used in 1964 had been discontinued.

In both studies students wrote a scholastic aptitude test and the Inventory of Choices, a measure of attitudinal orientation (Edwards and Wilson 1959a, 1959b) (Figs. 1&2). Almost three thousand students from 34 schools participated in the 1972 study.

Haggard's method of profile analysis, an adaptation of two-way analysis of variance, was used to analyze the residual chemistry scores; residual scores were defined as raw achievement scores in each Taxonomy category minus the corresponding score predicted from verbal and mathematical aptitude scores by appropriate regression equations. Components of the patterns also were examined for changes. These components consisted of aptitude and achievement scores, attitudinal orientation scores and sundry descriptive measures. Achievement patterns (Figures 3-6) were analyzed in terms of stabilized scores (S-scores) obtained by dividing each subtest score by its standard error of measurement. (Haggard, 1958, Chap. VII; Even, 1968, pp.98-100).

The principal findings were as follows:

1. During the period from 1964 to 1972 substantial declines in aptitude scores were observed (Table 1); these declines were greater in the general population than in the chemistry sample, and were greater in verbal aptitude than in mathematical aptitude. While the chemistry sample exhibited only a small decline in mathematical aptitude, the verbal decline was substantial.
2. Substantial declines in equivalent achievement scores were observed on the total score and in every subtest (Table 2). Taxonomy Category 1.00 (*Knowledge*) showed the most decline and Category 2.00 (*Comprehension*) showed the least. While some of the decline could be attributed to the drop in aptitude scores, declines persisted after the effect of lowered aptitude scores was taken into account.
3. Achievement in the *Knowledge* category was more variable in 1972 than in 1964. In the 1972 sample there were also more excessive deviations from the mean than in the case of a normal distribution, which the 1964 *Knowledge* scores closely approximate in kurtosis. The trend observed here is one of polarization, with 1972 students becoming either more prone to recall factual information as a cognitive strategy or less prone to recall facts than the 1964 group.

4. In the interval under study changes were observed in attitudinal orientation (Table 3). From 1964 to 1972 there were moderate to substantial shifts away from the Theoretic and Prudent orientations and toward the Immediate orientation, indicating, in the 1972 sample, less preference for activities of a deliberative nature and more preference for activities of a socially influenced and non deliberative nature. The typical class in chemistry in 1972 contained proportionately fewer students interested in the kinds of mental activities that scientists pursue, and proportionately more students who are vitally interested in and influenced by what peers do or say.
5. A substantial portion of the students (about 30%) in the 1972 sample had a pattern of achievement in which their performance in categories 2.00, 3.00 or 4.00 appeared to be tied to the ability to recall factual knowledge (category 1.00) (Figs. 3&4). Such a relationship was not observed in the 1964 sample where recalling specific information had no relationship to performance in the higher Taxonomy categories studied.
6. Normal achievers (i.e. those not classed as overachievers or underachievers) in the 1972 sample appear to have congruent patterns of achievement in categories 2.00, 3.00 and 4.00 whereas in 1964 the corresponding group was characterized by lack of uniformity in patterns of achievement.
7. In the 1964 sample distinctive patterns were observed amongst overachievers and underachievers (Fig. 4) and amongst highly Theoretic and highly Immediate non-normals (Fig. 6). In the 1972 samples (Figs. 3&5) these distinctive patterns disappear.
8. The overall decline for highly Theoretic non-normals is greater than that for their highly Immediate counterparts. (Figs. 5&6).
9. In the 1964 overachiever pattern (Fig. 4) and in the 1964 highly Theoretic non-normal achiever pattern (Fig. 6) a significant peak occurred at Category 3.00. In the 1972 patterns this peak at Category 3.00 disappears, to be replaced by a peak at Category 2.00 in all groups. Thus in the 1972 groups the most proficient skill occurs lower in the cognitive hierarchy than in the 1964 sample.

In addition to the general decline in achievement, the patterns of achievement show a move toward uniformity, both in the loss of distinctive patterns and in the appearance of factual recall as an integral part of the pattern of a large segment of the student population. There also appears to be a downshift in the cognitive achievement pattern so that the most proficient skill is lower in cognitive level than it was previously.

The effects observed are opposite to what the program was intended to accomplish. The findings thus are cause for concern, particularly in view of (1) the trend in modern science courses to minimize the dependence on factual recall and (2) the increasing awareness of the need to encourage and provide for individual differences. Moreover, should the observed trends in achievement and student characteristics continue, the present program will become increasingly inappropriate for its students.

References

Bloom, Benjamin S., et al. Taxonomy of Educational Objectives. Handbook I: Cognitive Domain. New York: David McKay Inc., 1956.

Edwards, T. Bentley, and Wilson, Alan B. "The Association Between Interest and Achievement in High School Chemistry." Educational and Psychological Measurement (Winter, 1959), 601-610. (a)

Edwards, T. Bentley , and Wilson, Alan B. "The Development of Scales of Attitudianal Dimensions." Journal of Experimental Education, 28 (September, 1959), 3-36. (b)

Even, Alexander. "Patterns of Academic Achievement in Grade 12 Chemistry and Their Relationship to Personal, Attitudinal and Environmental Factors." Unpublished Ph.D. dissertation, University of Toronto, Toronto, Ont., 1968. Dissertation Abstracts, 31, (1970) 1136-A. (Microfilm copy available from the National Library of Canada, Ottawa.)

Haggard, Ernest A. Intraclass Correlation and the Analysis of Variance. New York: The Dryden Press Inc., 1958.

Wright, Benjamin D. "Sample-free Test Calibration and Person Measurement." In Proceedings of the 1967 Invitational Conference on Testing Problems. Princeton, N.J.: Educational Testing Service, 1968.

Wright, Benjamin D., and Douglas, G.A. "Better Procedures for Sample-free Item Analysis." Research Memorandum No. 20, Statistical Laboratory, Department of Education, University of Chicago, 1975.

Wright, Benjamin D., and Panchapakesan, N. "A. Procedure for Sample-free Item Analysis." Educational and Psychological Measurement, 29, (1969) 23-48.

TABLE 1

COMPARISON OF SATO* SCORES FOR PRESENT AND PREVIOUS SAMPLES
RAW SCORES

Test	Group	N	Mean	SD
SATO Total Verbal	1974 Ontario Equating Group	379	23.57	8.31
	†1972 Chemistry Sample	2,431	23.82	8.20
	1964 Chemistry Sample	2,248	26.18	8.33
	1964 Ontario Grade 12 Population (General Course)	44,029	26.50	8.29
SATO Mathematics	1974 Ontario Equating Group	362	15.54	5.76
	†1972 Chemistry Sample	2,431	16.73	5.88
	1964 Chemistry Sample	2,248	17.05	5.69
	1964 Ontario Grade 12 Population (General Course)	44,016	17.18	5.69

*Scholastic Aptitude Test (Ontario), 1963-64 Edition.
†SATO Equivalent Scores, derived from SCAT-II 1A scores equated through the Ontario equating group.

TABLE 2

CHANGES IN CHEMISTRY ACHIEVEMENT
1964 to 1972

Test	1972 Sample N = 2431		1964 Sample N = 2339	Change, in 1964 Raw Score Units	Change, in 1964 SD Units
	Original 1972 Raw Score	Equivalent 1964 Raw Score	Raw Score		
Total Score					
No. of items	60	60	60		
Mean	23.18	21.20	25.15	-3.95	-.49
SD	8.35	8.05	8.13		
Tax. Cat. 1.00					
No. of items	15	23	23		
Mean	6.69	7.01	9.71	-2.70	-.77
SD	2.81	3.72	3.50		
Tax. Cat. 2.00					
No. of items	15	11	11		
Mean	6.59	4.87	5.25	-0.38	-.16
SD	2.78	2.00	2.32		
Tax. Cat. 3.00					
No. of items	15	14	14		
Mean	5.93	4.91	6.19	-1.28	-.49
SD	2.74	2.49	2.60		
Tax. Cat. 4.00					
No. of items	15	12	12		
Mean	3.97	3.21	4.00	-0.79	-.42
SD	2.09	1.62	1.87		

All changes in means significant at the .001 level
All changes in SD significant at the .05 level except for total score

TABLE 3

CHANGES IN ATTITUDINAL ORIENTATION
1964 to 1972

Scale	Mean 1972	Mean 1964	Change *	Direction of Change
Prudent-Theoretic	2.74 N = 2182	2.60 N = 2016	.14	Away from Theoretic
Prudent-Immediate	2.43 N = 1947	2.68 N = 1816	-.25	Toward Immediate
Prudent-Aesthetic	1.80 N = 2150	1.99 N = 1965	-.19	Away from Prudent
Theoretic Immediate	2.16 N = 2133	2.37 N = 1904	-.21	Away from Theoretic Toward Immediate
Theoretic Aesthetic	2.15 N = 2040	2.38 N = 1889	-.23	Away from Theoretic
Aesthetic Immediate	2.54 N = 1829	2.64 N = 1835	-.10	Toward Immediate

*All changes significant at the .01 level
No significant changes observed in variance.

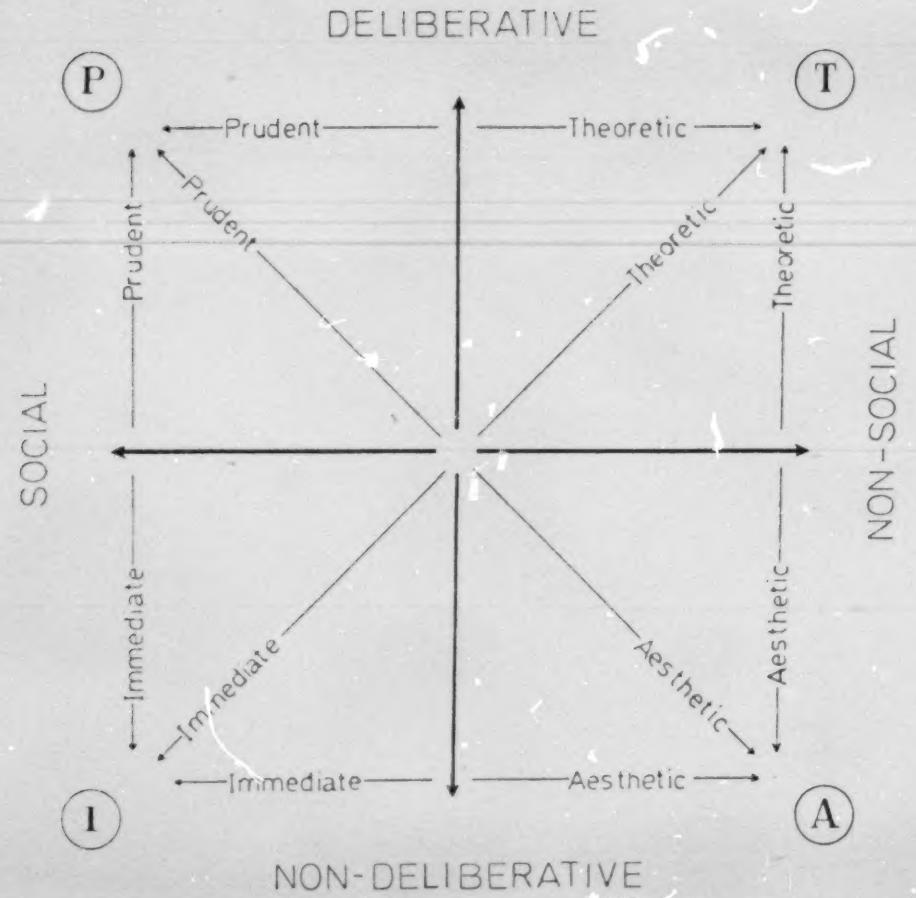

Fig. 1--Two-way Classification of
Interests according to Edwards and Wilson.

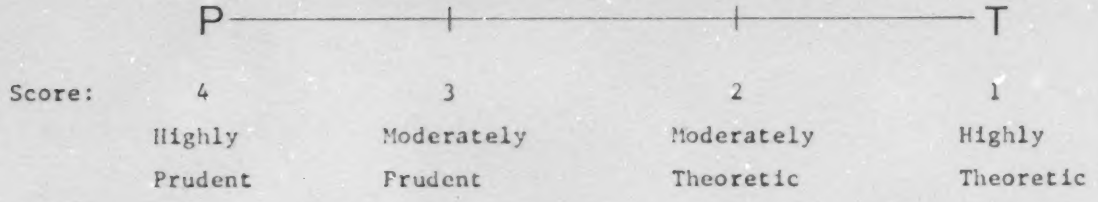

Fig. 2 - Interpretation of the Prudent-Theoretic Scale Scores

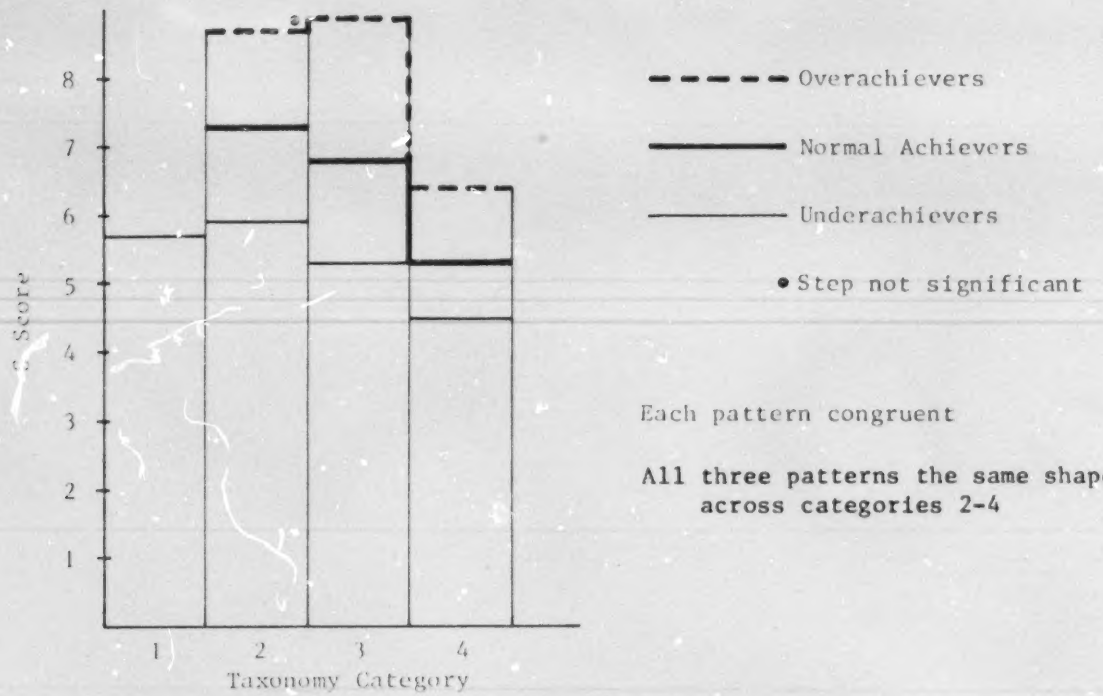

Fig. 3 – Patterns of Overachievers, Normal Achievers, and Underachievers 1972 Sample

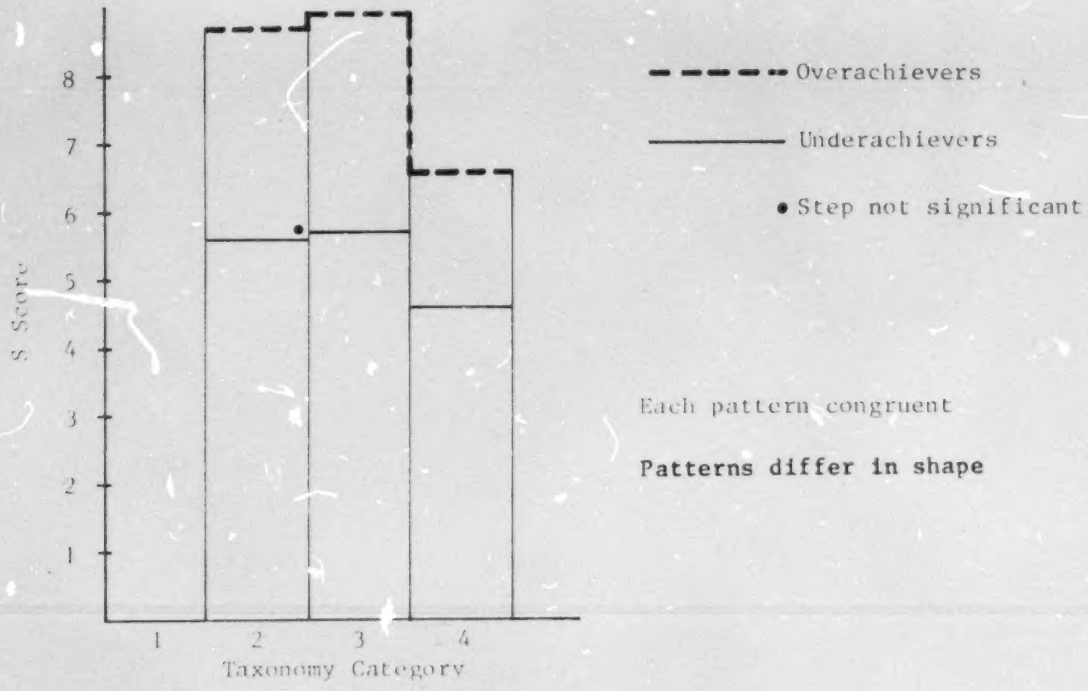

Fig. 4 — Patterns of Overachievers and Underachievers 1964 Sample

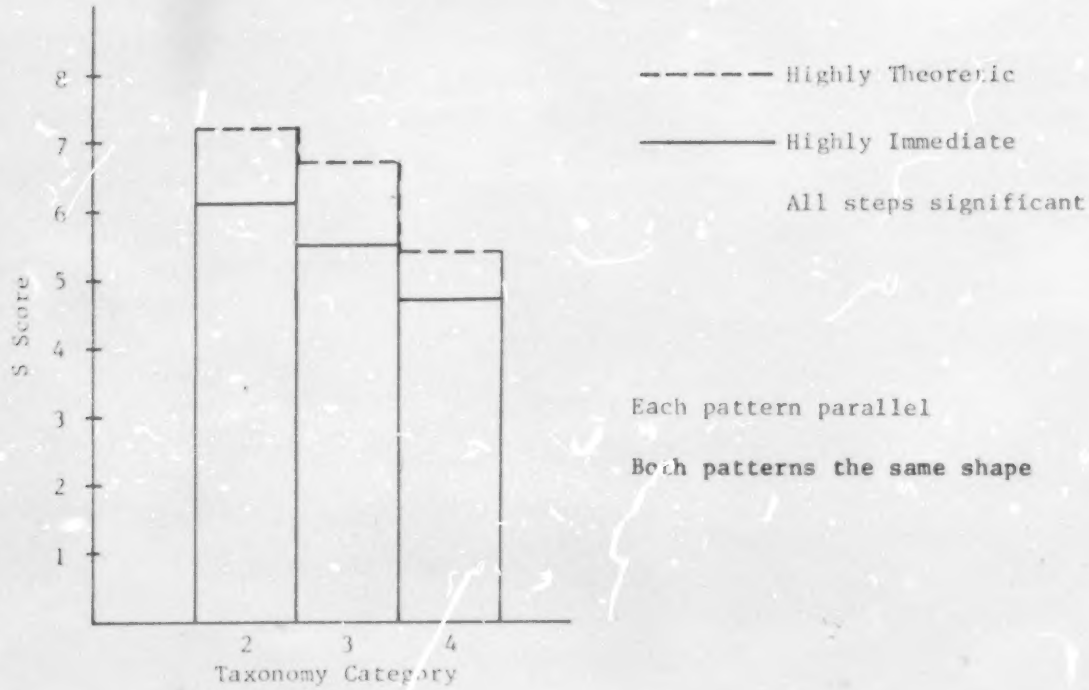

Fig. 5 - Patterns of Overachievers and Underachievers with Extreme Theoretic-Immediate Scores 1972 Sample

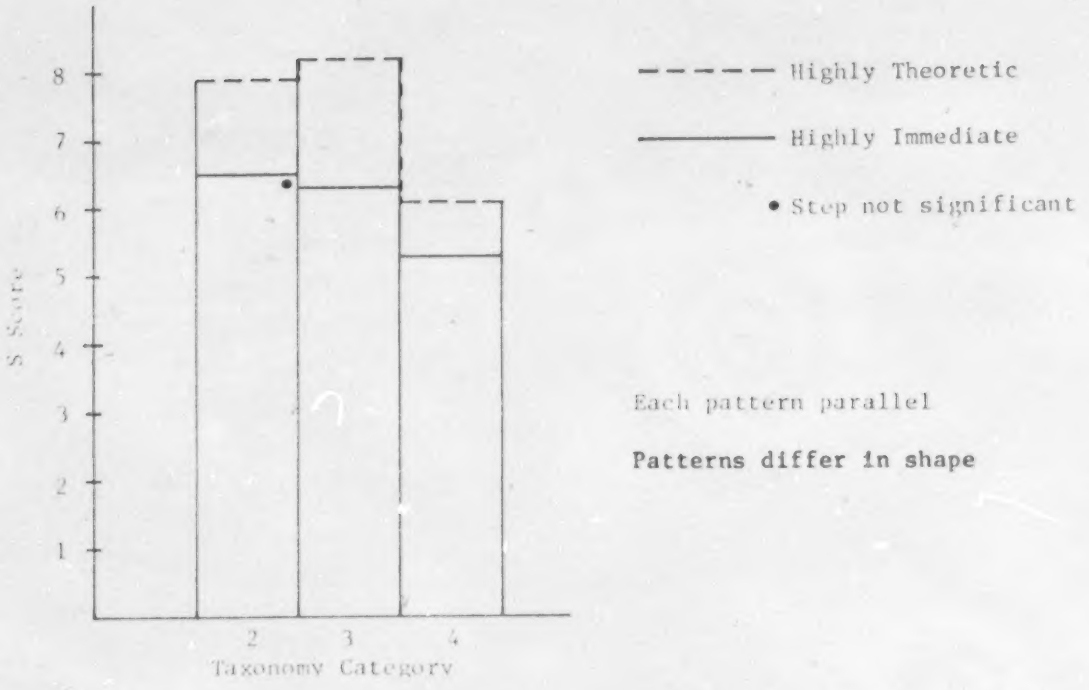

Fig. 6 - Patterns of Overachievers and Underachievers with Extreme Theoretic-Immediate Scores 1964 Sample